The Coevolution of Perceptions of Procedural Fairness and Link Formation in Self-Organizing Policy Networks

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A key variable to foster cooperation in groups is the perception among members that the process of making decisions is fair to everyone involved, yet little is known about how these perceptions coevolve with the interactions that take place within the groups. In this article, I use a stochastic actor-oriented model to examine the coevolution of perceptions of procedural fairness and the establishment of relationships among organizations in self-organizing policy networks in five U.S. estuaries. These networks form and evolve as their members seek to address important environmental problems that affect multiple jurisdictions. Findings show that participation in networks does not affect perceptions of procedural fairness; instead, the latter affect the former, i.e., stakeholders create ties with other actors with similar perceptions of how fair decision-making processes are. These results have important implications for our understanding of how governance institutions should be designed to find collaborative solutions to policy problems.

Conflict is likely to occur in groups whenever multiple actors seek to achieve different goals, and so social scientists have invested considerable efforts examining the variables that can increase the likelihood of cooperation in such situations. One critical variable that has been identified as a key antecedent to cooperation is the perception of procedural fairness among the members of a group—the belief that the process of making decisions is fair to those involved in it. Perceptions of higher procedural fairness are thought to ease conflict because they facilitate the emergence of group-level identities that increase the likelihood of cooperation (Tyler and Blader 2002, 2003).[1]

Previous research assumed that individuals favored fair procedures in intragroup interactions because they believe that this would lead to a fair distribution of resources (Thibaut and Walker 1975). However, subsequent findings demonstrated that perceptions of higher procedural fairness led to lower conflict *even when the actors did not entirely agree with the distributional outcomes* of the decision-making processes (Bolton, Brandts, and Ockenfels 2005). This positive effect of the perception of procedural fairness on dampening conflict has led some to claim that institutions must be designed with an eye toward the establishment of procedural rules that are considered to be fair by the majority of participants (Lind and Tyler 1988).

Research in political science has also examined the effect of perceptions of procedural fairness on decision-making processes. For instance, Tyler, Caspers, and Fisher (1989) showed that individuals who perceive processes to be fair tend to show more allegiance to legal authorities.[2] In addition, studies of collaborative partnerships and policy networks dealing with the management of natural resources have explored the relationship between perceptions of procedural fairness and variables that are thought to foster cooperation. For instance, Leach and Sabatier (2005) reported that perceptions of procedural fairness among participants in

[1]The data used in this article were obtained with NSF grant SBR97295905. An online appendix with supplementary material can be found at www.journals.cambridge.org/jop. Replication materials can be found at www.u.arizona.edu/~berardo/research.htm.

[2]Gibson (1989) failed to find evidence that perceptions of procedural fairness *directly* affect the willingness to comply with decisions reached by local legislatures, local courts, and even the U.S. Supreme Court, but he asserted the possibility that procedural fairness affects the willingness to comply *indirectly* through its effects on other mediating variables (Gibson 1991).

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watershed partnerships in the United States significantly increased the level of trust that the participants exhibit toward others. Lubell (2003) examined the perceptions of policy effectiveness in multistakeholder partnerships in 22 estuaries in the United States and discovered that individuals who perceive high levels of procedural fairness tend to believe that problems are dealt with in a more effective way, hence inducing a favorable environment for real collaboration.

In these studies, procedural fairness was one of *the* most important variables explaining trust and policy effectiveness. However, a limitation of this line of research is that it has not examined the dynamic relationship between the perceptions of procedural fairness and how the stakeholders interact with each other in self-organizing networks. In other words, it remains unclear whether perceptions of procedural fairness drive network activity or the other way around. This is an important shortcoming because a better understanding of this dynamic relationship could provide valuable information to decision makers with the capacity to steer networking processes in ways that facilitate the occurrence of collaborative behavior.

For instance, if actors who are more integrated or participate more in networks tend to perceive higher levels of procedural fairness, then a possible line of action would be to create proper venues where stakeholders could strengthen their interactions with each other and voice their opinions about how to address common problems. This could positively affect perceptions of procedural fairness, thereby increasing the likelihood of reaching meaningful cooperation (Schneider et al. 2003).

Using network analysis, we can also improve our understanding of the relationship between perceptions of procedural fairness and network activity by examining whether social selection (homophily) or social influence effects are prevalent. Social selection or homophily happens when network connections are a function of the similarity of individual attributes (e.g., similar perceptions of procedural fairness between two actors increase the likelihood that they will connect with each other), whereas social influence takes place when the causal direction is reversed and the existence of a tie explains how the individual attributes of the actors change. Obviously, figuring out which type of effect is more pervasive could have different implications for how to go about trying to improve governance at a regional scale. If social influence is prevalent and opinions about the procedural fairness of decision-making processes travel through network ties (in other words, if perceptions are ''contagious''), then policy makers and bureaucrats interested in improving regional governance would be better off identifying the actors who perceived the processes to be very fair and making sure they have the resources to become highly central in their communication networks. On the other hand, if social selection is predominant and the similarity of the actors' opinions about procedural fairness precedes and explains the building of connections, then those with the capacity to affect the network architecture should probably invest heavily in trying to avoid the excessive fragmentation of the network that would result from actors clustering with those that hold similar opinions. This could be done more effectively, for example, if actors with particularly negative views about procedural fairness could still be somehow convinced to remain committed to finding solutions to problems in concert with other actors for whom procedural fairness is not a problem.

To analyze the dynamic relationship between the perceptions of procedural fairness in self-organizing policy networks and the structure of such networks, I fit a stochastic actor-oriented model (Snijders 2001; Snijders, van de Bunt, and Steglich 2010) to the informal networks (or partnerships) that form and develop in five estuaries of the United States. Estuaries, geographic areas where the fresh waters of a river meets the salty water of the ocean, are excellent scenarios to study cooperation issues because they are often subject to ''wicked'' (complex) policy problems that appear when human users of natural resources have conflicting priorities and that are usually exacerbated by the fragmented nature of local and state-level regulations (Berardo and Scholz 2010; Schneider et al. 2003; Scholz, Berardo, and Kile 2008). Given that solutions to these problems demand collaboration among a myriad of stakeholders, studying the coevolution of perceived procedural fairness and organizational interactions in the estuaries is important because uncovering the nature of such relationships may help explain the success (or failure) in addressing such complex problems.

Perceptions of Procedural Fairness and Participation in Networks

Particularly in social psychology, there is an extended tradition of the study of perception of procedural fairness, which is believed to diffuse conflict because it gives actors the sense that their opinions and views are effectively taken into account when decisions are made (Brockner et al. 1998; De Cremer and Tyler 2007; De Cremer, Tyler, and den Ouden 2005; Folger 1977; Thibaut and Walker 1975, 1978; Tyler and

Blader 2003, Van den Bos and Lind 2002, among others). The effect of perceptions of procedural fairness on individual behavior has also been studied in other disciplines. For instance, research on management accounting procedures has shown that perceptions of procedural fairness in organizations positively affect job satisfaction and organizational commitment (Lau and Tan 2005), while studies on taxpayer behavior have shown higher tax compliance when individuals regard their treatment by the taxing authority as fair (Hartner et al. 2008; Murphy 2005; Wenzel 2002; among others).

As mentioned in the introduction, political scientists have also studied the relationship between perceptions of procedural fairness and attitudinal traits (trust) and opinions (assessments of effectiveness of partnerships) that may facilitate collaborative behavior among organizations (Leach and Sabatier 2005, Lubell 2003). However, no efforts have yet been made to find out whether the patterns of participation of the actors in the partnerships have an effect on how perceptions of procedural fairness are shaped and vice versa. I address this shortcoming by presenting and testing different hypotheses that link particular patterns of participation in networks to the perceptions of procedural fairness of the participants. Some of these hypotheses take the changes in perceptions as dependent on the way in which actors connect to others in their networks, while others see network connections as dependent on perceptions of fairness. Taken together, these hypotheses conceive the relationship between perceptions of procedural fairness and network building as an inherently dynamic one.

Perceptions of Procedural Fairness Dependent on Network Activity

Scholars have argued that members of a group will perceive higher levels of procedural fairness when they are highly *integrated* in the group because this gives them the ability to make their positions known to others (Kanfer et al. 1987; Lind et al. 1978; Tyler, Rasinski, and Spodick 1985). Integration in this sense does not mean simple membership in a group but rather the possibility for an actor to make her positions known to others, thus increasing the likelihood of having a say in critical decisions that affect the whole group. It is this integration that makes actors more prone to regard the process as procedurally fair because it is less likely that their opinions will be disregarded by others (Brockner et al. 1998; Folger 1977).

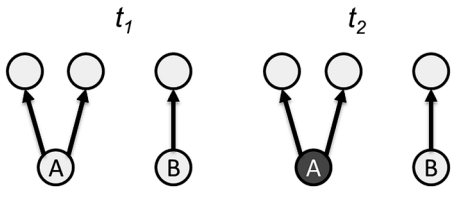
The argument can be easily adapted to the self-organized interorganizational networks or partnerships that I examine in this article. It should be expected that individuals working in organizations that are more active in approaching other actors will perceive more procedural fairness because the chance that their organizational goals will be unaccounted for in decision-making processes should decrease.

In the estuaries networks, the simplest way of measuring organizational integration is by calculating the out-degree of the organization (or the count of links that the organization directs to other actors in the network), which represents its level of activity. A link directed from one organization to another indicates the former's effort to establish a communication link with the latter, and the more links the organization creates, the more integrated it is in the network. In Figure 1, organization A is more linked (integrated) in t_1 than organization B, and as a consequence, it raises its perception of procedural fairness in t_2 (higher perception of procedural fairness in this and other figures is represented by a darker coloring of the node).

> *H1 (Integration Hypothesis)*: Actors who are more integrated (higher out-degrees) will perceive higher levels of procedural fairness in comparison to those who are less integrated (have lower out-degrees).

While scholars have taken particular attention to examine how being integrated in a group increases perceptions of procedural fairness, complementary research has shown that perceptions of procedural fairness may be affected not so much by the capacity of the actor to make its position known to others, but rather by its standing in a group in terms of *status.* Actors enjoying higher status in a group are more likely to benefit from their position, which in turn could positively affect their perceptions about the inner functioning of the group (Tyler and Blader 2002; Tyler and Lind 1992; van Proijen, van den Bos, and Wilke 2002). For instance, Tyler (1994) showed that individuals who interacted with public authorities and their supervisors at work were more likely to consider procedures fair when they perceived that they were treated with respect and deference, which the author contends are indicators of status in a relationship.

FIGURE 1 Integration and Perceived Procedural Fairness



Testing this relationship in the estuaries partnerships demands a decision on how to measure status, which is a nontrivial issue in network studies (Wasserman and Faust 1994). For the sake of simplicity, in this article I utilize the most straightforward measure of status: the in-degree of the actor (ties that the actor receives from others). The in-degree centrality is particularly well suited to capture status or prestige when one observes informal networks such as those that form and develop in the estuaries that I study, where there are no mandated links forced upon the nodes by a higher authority figure. In this context, the in-degree of a node is the simplest way of capturing how important that organization is in comparison to other nodes that are also a part of the network. Support for the status hypothesis would require that individuals working for organizations with a higher in-degree centrality adjust their perceptions of procedural fairness upward over time, as shown in Figure 2.

H2 (Status Hypothesis): Actors with more status (higher in-degrees) will perceive higher levels of procedural fairness in comparison to those with less status (lower in-degrees).

In addition to the previous two hypotheses, I present a third hypothesis that links the perceptions of procedural fairness exhibited by actors to the perceptions of procedural fairness held by those with whom the actors interact. In settings where multiple actors interact with each other, it is possible that the behavior of the actors is shaped by those that form their "social environment." If such a process of social influence is in place, then the actors may tend to become more like those with whom they interact, since network ties serve as a conduit through which perceptions, attitudes, and other individual attributes can spread (see Figure 3). Social influence has been invoked to explain a wide range of microlevel behaviors, including individual levels of military discipline (De Keppler et al. 2009), feelings of happiness (Fowler and Christakis 2008), substance abuse (Steglich, Snijders, and Pearson 2010), and adoption of group-prevalent behavior through conformity effects (Boyd and Richerson 1985; Henrich and Boyd 1998), among others.

FIGURE 2 Status and Perceived Procedural Fairness

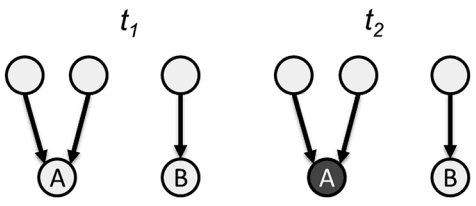
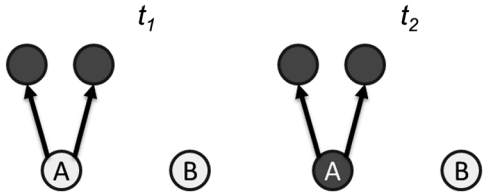


FIGURE 3 Social Influence and Perceived Procedural Fairness



The study of social-influence processes is, of course, common in political science and sociology, dating back to the classic studies of voting behavior in the 1940s and 1950s that showed how individual voting decisions are conditional on the voters' social relationships (Berelson, Lazarsfeld, and McPhee 1954; Lazarsfeld, Berelson and Gaudet 1944). The nuances of the process of political assimilation that leads to individuals becoming more similar to their social contacts has been studied in detail (Huckfeldt 1986; Huckfeldt and Sprague 1991; Lazer et al. 2010; among others), with considerable evidence showing that opinions tend to converge among individuals who belong to the same social groups.[3] Evidence of social influence also exists in the mobilization of social movements (Chwe 1999; Kim and Bearman 1997; Oliver and Myers 2003) and in the popular literature on the diffusion of policy innovations among states and local governments (e.g., Berry and Berry 1990, 1992; Gray 1973; Volden 2006).

In the case of the estuaries networks that I examine in this article, I posit that social influence processes could also take hold because a by-product of collaborative relationships is the progressive sharing of policy views and perceptions about the environment in which the actors interact (Termeer and Koppenjan 1997). As actors engage in collaborative relationships with others, they could adapt their views of the world to the vision held by others, an effect that should be amplified when the actor has many partners who share a common view.

H3 (Social-Influence Hypothesis): Over time, actors will adjust their perceptions of procedural fairness to that of their contacts in the network.

[3]There are different terms in the literature to brand this convergence process, including "assimilation," "contextual influence," "social influence," "political convergence," "social learning," etc. For evidence of the lack of convergence in political behavior, even in the presence of mounting pressure from an individual's social environment, see Huckfeldt, Johnson, and Sprague (2004).

The Dependence of Network Activity on Perceptions of Procedural Fairness

The three hypotheses in the previous section argue that the participation of actors in groups affects their perceptions of procedural fairness, and in this sense, they only provide an incomplete picture of the dynamic relationship between those variables because the latter can also affect the former. I present two additional hypotheses that address the formation of ties as dependent on perceptions of procedural fairness: the Legitimacy Hypothesis and the Homophily Hypothesis.

Researchers of procedural fairness have shown that individuals who perceive processes to be fairer regard those processes as more legitimate, which in turn results in a higher likelihood of engaging in cooperative behavior (Murphy 2005). Legitimacy is also considered by network scholars as a key component to favor engagement in networks (see, for example, Provan and Kenis 2008), and so actors who regard a network as characterized by fair decision-making procedures should become more active, both in the creation and the reception of ties (see Figure 4).

> *H4 (Legitimacy Hypothesis)*: Actors who perceive higher procedural fairness will be more active in the network (increasing both their in-degrees and out-degrees scores) in comparison to those who perceive lower procedural fairness.

Finally, a fifth hypothesis links the formation of ties to the similarity in the perceptions of procedural fairness between the members of a dyad. Network scholars interested in the coevolution of network ties and individual-level behavior have paid abundant attention to the presence of selection effects or homophily in networks, which is the tendency of actors to create ties with similar counterparts (Weick 1979; see McPherson et al. 2001 for an outstanding review of the concept and applications).

In public management and policy studies, homophily has received attention—though not always explicitly—as one of the driving forces in the creation of ties in networks (see, for example, Henry et al. 2011; Termeer and Koppenjan 1997). One of the main assumptions in Advocacy Coalition theory, for instance, is that policy actors build ties to others with whom they share similar policy beliefs because this reduces transaction costs and helps newly formed coalitions in focusing their resources on the shaping of policy agendas, which is their ultimate goal (Sabatier and Jenkins-Smith 1993; Weible 2010).

In the estuaries networks, it is plausible that ties between organizational actors are formed based on their similar perceptions of procedural fairness simply because relationships in self-organized networks are commonly embedded in shared views of the variables that favor—or impede—governance at a regional scale (Scholz and Stiftel 2005) (see Figure 5). Thus, the last hypothesis can be stated as follows:

> *H5 (Homophily Hypothesis)*: Actors will create ties to alters (actors) who have similar perceptions of procedural fairness.

With this in mind, it is important to notice that the presence of either *homophily* or *social influence* could indicate that obstacles exist to finding solutions to problems in the estuaries that are interjurisdictional in nature. After all, both *homophily* and *social influence* could lead to a partition of the network in different camps with those who think procedural fairness is high on one side and those who think procedural fairness is low on the other. In the long term, this would obviously have negative effects on the capacity of networks to contribute to the solution of collective-action problems in the management of the natural resources in the estuaries.

FIGURE 4 **Legitimacy and Network Activity**

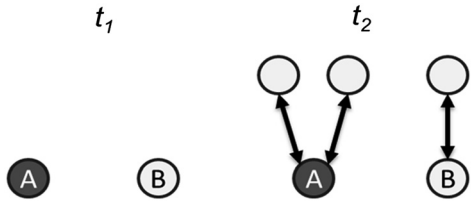
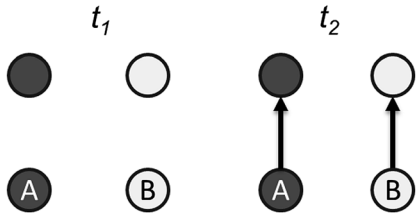


FIGURE 5 **Homophily (selection) and Network Activity**



Research Design

I test these hypotheses through the estimation of a stochastic actor-oriented model (SAOM) for network dynamics (Snijders, van de Bunt, and Steglich 2010) in five U.S. estuaries where organizational actors (egos) can create or destroy already existing ties to other actors (alters) and also change their perceptions

of procedural fairness as time unfolds. An advantage of SAOMs is that they allow for the estimation of the coevolving process through which actors in a network change their behavior, but they also create, maintain, or destroy ties with others (the longitudinal analysis in this case is made possible due to the fact that data were collected at two different points in time: 1999 and 2001). The examination of the coevolving process is accomplished through the estimation of both a *behavioral evaluation function* that estimates how actors in a network change a given behavior or attitudinal trait—the perception of procedural fairness in this case and a *network evaluation function* that models changes in the formation of ties (Steglich, Snijders, and Pearson 2010).

The *behavioral evaluation function* that I estimate adopts the following form for an ego i;[4]

$$\begin{aligned} u_i^{\text{beh}} = {} & \beta_1 z_i \textstyle\sum_j x_{ij} + \beta_2 z_i \sum_j x_{ji} \\ & + \beta_3 \textstyle\sum_j x_{ij}(\text{sim}_{ij}^z - \text{sim}_{\text{ave}}^z) \\ & + \textstyle\sum_k \beta_k^{\text{beh}} s_{ijk}^{\text{beh}}(x_{ij}) + \varepsilon^{beh} \end{aligned} \tag{1}$$

The first term represents the likelihood that the actor will adjust its perception of procedural fairness based on its out-degree, and so it tests the *integration hypothesis*; z_i is the centered value of perception of procedural fairness of actor $_i$ and x_{ij} is equal to 1 if there is an edge (a directed tie) from ego $_i$ to alter $_j$, and 0 if there is none.[5] The second term represents the likelihood that the node will adjust its perception of procedural fairness based on its in-degree, which serves as a test of the *Status Hypothesis*; in this term, x_{ji} represents an edge (directed tie) from alter $_j$ to ego $_i$, with a value of 1 again representing the existence of the tie and 0 representing its absence. The third term represents the likelihood that the node will adjust its perception of procedural fairness to the perceptions of those with whom it interacts (the *Social Influence Hypothesis*); in this term, $sim_{ij}^z = (\Delta - \mid z_i - z_j \mid)/\Delta$, where $\Delta = \max_{i,j} \mid z_i - z_j \mid$, which is the observed range of the ''perception of procedural fairness'' variable (more detail in the measurement of variables is given in the following section); $\text{sim}_{\text{ave}}^z$ is the mean of all similarity scores and equals $(1/n(n-1)) \sum_{i,j} sim_{ij}^z$. The term $\sum \beta_k^{\text{net}} s_{ijk}^{\text{net}}(x_{ij})$ represents the inclusion of k other effects[k] in the function to model how actors modify their perceptions of procedural fairness. These additional effects will be briefly discussed in a later section. Finally, ε^{beh} is the stochastic error term for the function.

The *network evaluation function*, on the other hand, represents the attractiveness of different network configurations to the ego and thus allows for the test of Hypotheses 4 and 5. The function adopts the following form:

$$\begin{aligned} u_i^{\text{net}} = {} & \beta_4 v_i x_{i+} + \beta_5 \textstyle\sum_j x_{ij} v_j + \beta_6 v_i \sum_j x_{ij} v_j \\ & + \textstyle\sum_k \beta_k^{\text{net}} s_{ijk}^{\text{net}}(x_{ij}) + \varepsilon^{\text{net}} \end{aligned} \tag{2}$$

Here, the first term represents the tendency of the ego to link to others based on its own perception of procedural fairness (the term is defined as the ego's out-degree weighted by its centered covariate value), while the second term captures the likelihood of the formation of links based on the alters' perceptions. According to the *Legitimacy Hypothesis* (Hypothesis 4), the actors who perceive higher procedural fairness should be more active in the network, and so the coefficients for these two terms should be positive and significant. The third interactive term is included to test H5 (the *Homophily Hypothesis* based on perceptions of procedural fairness). Since SIENA centers the scores of variables measured on interval scales as explained in footnote 5, a positive effect for this interaction term will signal the tendency of actors to create more connections to others who score similarly in the variable (either at higher or lower values). Like before, $\sum_k \beta_k^{\text{net}} s_{ijk}^{\text{net}}(x_{ij})$ represents the inclusion of k other effects that may help explain how actors in the network decide to build, maintain, or destroy links (the following section provides more details on these effects), and ε^{net} is the stochastic error term in the function.

To perform the estimation of the model containing both the network and the behavioral evaluation functions, the stochastic actor-oriented model relies on a Markov Chain Monte Carlo (MCMC) estimator that treats data collected in 1999 and 2001 as snapshots of an underlying process in which changes in both network connections and perceptions of procedural fairness are assumed to reflect ongoing individual ''microadjustments'' made by the actors between the two moments. The estimation consists of many simulated steps in which an actor is randomly selected and has the possibility of changing at most one connection or one level in the scale of perceived procedural

[4]Table A1 in the online appendix contains a description of each term in the function. A detailed discussion of all the terms in the function is available from the SIENA manual (http://www.stats.ox.ac.uk/~snijders/siena/).

[5]SIENA centers values for variables measured on interval scales. For each node, this is done by taking its score for the variable and then subtracting from it the mean value scored by all nodes in the network.

fairness. The goal of the estimation is to produce the set of coefficients for all the effects included in both the network and behavioral evaluation functions that most successfully reproduce the observed changes in the network structure and the perceptions about procedural fairness that take place between the two observation points. The model also estimates a rate parameter that determines the average number of discrete choices an actor makes in order to account for the observed changes in links between periods (see Snijders, van de Bunt, and Steglich 2010 for more information about the estimation procedure).

Other Effects Included in the Network and Behavioral Evaluation Functions

In addition to the effects that I discussed in the previous section, there are other effects in the model of coevolving tie formation and perceptions of procedural fairness. With regard to the creation of ties, actors in the self-organizing networks that this article examines may engage in a *search* strategy to gather novel information about the problems that they face, but they can also choose to be part of clustered, denser local configurations that create bonding social capital and trigger sustained long-term cooperation (more information about how these two strategies may coexist is available in Berardo and Scholz 2010). To model these two strategies, I include three parameters in the network evaluation function that assess whether actors (1) seek to build ties to popular alters, (2) reciprocate connections, and (3) engage in transitive triplets. The first effect is included to find out whether actors pursue a *search* strategy, whereas the other two effects are included to detect if actors build bonding structures that help avoid defection.

The network evaluation function also includes three effects to account for the formation of ties based on whether the actors are governmental or nongovernmental: "*government alter*," "*government ego,*" and "*government actor homophily*." Governmental actors are usually an important source of information for other actors about numerous important issues in estuaries (for instance, where to locate sources of funding for water-management projects, how to gather information about regulations that affect the stakeholders' range of activities, etc.), and so the expectation is that the "*government alter*" effect will be positive and significant, reflecting the fact that governmental actors will have higher in-degrees (more incoming ties) than nongovernmental actors. On the other hand, one must also keep in mind that governmental actors are usually endowed with larger budgets and bigger staffs to deal with environmental issues when compared to nongovernmental actors, and so I include a "*government ego*" effect to find out whether governmental actors are more likely to create more ties (higher out-degree) than nongovernmental actors. The "*government actor homophily*" effect (or homophily by organizational type) complements the effect that tests for homophily based on perceptions of procedural fairness (Hypothesis 5). Homophily may take hold based on changing or nonchanging features (like the perception of fairness or the organizational type respectively), and so the inclusion of this effect helps to assess more comprehensively how homophily may occur, if in fact it does.[6]

Since this study uses data collected in five different estuary networks, I include in the network evaluation function four dummy "ego" effects that distinguish each of the estuaries (Atchafalaya is left out as a baseline category). The inclusion of these dummy variables is akin to the estimation of estuary fixed effects; they represent the assumption that out-degree effects (activity levels) are different between the estuaries, while all the other parameters in the network evaluation function are the same.

Finally, in the behavioral evaluation function, I include tendency parameters (linear and quadratic) that model the evolution of the actor's perception of procedural fairness in time. The linear parameter models the existence of an upward trend in perception, and the quadratic shape is added to test whether the upward drive decreases as perception increases. In other words, this parameter captures the effect of perception of fairness on itself (Steglich, Snijders, and Pearson 2010). I also include the four estuaries' dummy variables in the behavioral function to examine whether there are differences between them in the evolution of the perception of procedural fairness. Finally, a dummy variable indicating whether an actor is governmental or not is also included in the model to control for the possibility that governmental actors tend to regard decision-making processes as more fair when compared with nongovernmental actors who usually have less resources to spend in these processes.

Data

I apply this model of coevolution of behavioral change and network dynamics in five U.S. estuaries

[6]This distinction is analogous to that established by Lazarsfeld and Merton ([1955] 1978) between value-homophily (based on attitudinal traits) and status-homophily (based on sex, age, etc.) in the formation of social relationships between individuals.

TABLE 1 Networks Statistics

	Atchafalaya	Cape Fear	Pensacola	St. Andrews	St. Johns River
Size	13	24	25	20	15
Density					
1999	0.20	0.05	0.06	0.09	0.11
2001	0.13	0.09	0.07	0.12	0.17
Average Degree					
1999	2.38	1.17	1.36	1.70	1.53
2001	1.60	2.05	1.67	2.36	2.36
Weighted Cluster Coefficient					
1999	0.23	0.08	0.10	0.17	0.27
2001	0.16	0.13	0.14	0.25	0.27

Overall Statistics (five networks together)	**1999 (t_1)**	**2001 (t_2)**
Average degree by node	1.55	1.57
Number of total ties	150	144
Number of mutual dyads	18	17
Number of asymmetric dyads	114	99

Change in Links from 1999 (t_1) to 2001 (t_2)					
$0 \rightarrow 0$	$0 \rightarrow 1$	$1 \rightarrow 0$	$1 \rightarrow 1$	Distance	Missing $t1 \rightarrow t2$
8617	84	62	60	146	489 (5%)

Note: Category $0 \rightarrow 0$ includes structural zeroes. Nodes with missing data (in 2001), are removed from the calculations in this table. This explains why the average degree by node is higher in 2001 than in 1999 despite the fact that the number of total ties is lower in 2001.

where data were collected in 1999 and 2001.[7] For each of the estuaries, the research team performed "seed" interviews with stakeholders who were contacted over the phone and asked: "Please think about three people on whom you have relied most heavily in dealing with estuary issues during the past year. Consider the full range of stakeholders, including government agencies, interest groups, and local officials. Please write the name of the organization your contact works with in the space provided." The responses were used in a snowball sampling procedure that continued to identify additional organizations and key respondents, which were then phoned to answer the questionnaire. The procedure rendered a total of 97 organizations associated with the five estuaries.[8]

Each reported contact represents a directed link from the respondent's organization (ego) to the named organization (alter). The directed links are aggregated into two binary square matrices that represent the contact networks in 1999 and 2001 and which contain a "1" in a given cell $_{ij}$ when there is a tie originated in the organization in row $_i$ that reaches the organization in column $_j$, and "0" when there is no such link. The five estuaries are represented in these full matrices by five blocks along the diagonal; outside these blocks the matrices include structural zero values to indicate that relationships are not allowed between actors in different estuaries. The two full matrices are built this way to allow for pooled estimations across the five different estuaries. Table 1 presents basic network statistics for descriptive purposes (Figure A1 in the online appendix contains a visual representation of the five networks in t_1 and t_2).

Except Atchafalaya, the remaining four estuaries experienced a growth of density from t_1 to t_2. This increase in density was coupled by a growth in the clustering coefficient as well, except in the case of Lower St. Johns River, where the clustering coefficient remained stable. These differences do not necessarily affect the theoretical arguments summarized in the hypotheses, but the fact that the network for Atchafalaya seems to be moving in the opposite direction than the others warrants caution in any analysis including it; thus the inclusion of the estuary dummies that I described in the previous section seems to be particularly relevant.

Measurement of Variables

Perception of Procedural Fairness is measured with the mean responses to two questions in the survey.

[7]For more information about data collection, see Schneider et al. (2003). The estuaries are Atchafalaya Bay (LA), Cape Fear (NC), and Pensacola Bay, Lower St. Johns River, and St. Andrews Bay (FL).

[8]These five estuaries are a subset of a larger group of estuaries that were studied in the original project. The five I include here are the ones with fewer missing data in the second period of data collection (between 20 and 28% of the respondents in the first wave were not reached during the second wave).

First, the respondents were asked to agree or disagree with the following statement: "Overall, the decision-making process in the partnership is fair to all stakeholders." The responses range from 0 (complete disagreement) to 10 (complete agreement). The second statement is "my organization's interests and concerns are adequately represented in the partnership."[9] Again, the agreement level spans from 0 (complete disagreement) to 10 (complete agreement). The mean value obtained across all 97 nodes in the networks was 5.50 for t_1, and 5.32 for t_2 (overall mean of 5.41[10]). From the first wave of data collection to the second wave, 34 nodes downgraded their perception of procedural fairness, 23 upgraded it, and 17 remained constant (there are missing data for the remaining number of nodes for t_2).

Government actor is a dichotomous variable with a value of 1 if the organizational actor is governmental and a value of 0 if it is nongovernmental. A total of 50 actors, out of the 97 that are part of the networks in the five estuaries, are governmental. As explained in footnote 4, all individual values are centered by SIENA during runs to estimate models.

Results

The estimation of the model is performed in SIENA (Simulation Investigation for Empirical Network Analysis), a computer software program that implements stochastic actor-oriented models for the study of network dynamics (Snijders et al. 2008). Table 2 shows the results of the estimation of the model (the complete output from the estimation can be found at www.u.arizona.edu/~berardo/research.htm).[11] The coefficients represent log odds ratios.

Overall, the results show that the typical explanations of what leads to higher perceptions of procedural fairness do not find an empirical correlate in the estuaries' networks. Neither the Integration Hypothesis (Hypothesis 1) nor the Status Hypothesis find support in the empirical analysis, since egos with higher out-

TABLE 2 Longitudinal Analysis of Self-Organizing Network Structures in Five Estuaries, 1999–2001

Variables	Coefficients (standard error)
Behavioral Evaluation Function (effects on perception of procedural fairness)	
Integration (effect of ego's out-degree)	-0.12
	(0.13)
Status (effect of ego's in-degree)	0.01
	(0.03)
Social influence (total similarity with alters)	2.19
	(1.43)
Cape Fear effect (dummy)	0.07
	(0.20)
Pensacola effect (dummy)	0.06
	(0.21)
St. Andrews effect (dummy)	-0.01
	(0.22)
Lower St. Johns effect (dummy)	-0.06
	(0.24)
Government actor effect (dummy)	0.04
	(0.13)
Linear shape (tendency)	0.07
	(0.19)
Quadratric shape (effect of perception of proceeding fairness on itself)	-0.01
	(0.03)
Rate of change (average choices per actor to modify perceptions)	8.40***
	(2.73)
Network Evaluation Function (effects on network activity)	
Legitimacy (effect of ego's perception of procedural fairness on link formation)	-0.08
	(0.11)
Legitimacy (effect of alter's perception of procedural fairness on link formation)	0.07
	(0.09)
Homophily based on perception of procedural fairness Interaction effect (ego's perception x alter's perception)	0.13**
	(0.06)
Government ego effect (dummy)	-0.24
	(0.25)
Government alter effect (dummy)	0.44**
	(0.22)
Government actor homophily effect	0.51**
	(0.21)
Reciprocity	0.83*
	(0.49)
Transitive triplets	0.21
	(0.17)

[9]Cronbach's Alpha values are .76 for data collected at t_1 and .82 for data collected at t_2.

[10]The overall mean is used to center the individual scores (see footnote 5). For example, a node *i* that scores a value of 6 for perception of procedural fairness in t_1, would receive a centered score of 0.59 (since the mean score is 5.41).

[11]Given the stochastic nature of the estimation algorithm, I estimated the model five different times. The results are extremely similar in terms of the relative size of coefficients, their signs, and significance levels.

TABLE 2 (Continued)

Variables	Coefficients (standard error)
Popularity of alter based on its in-degree	0.26** (0.05)
Popularity of alter based on its out-degree	-0.11 (0.27)
Out-degree (density)	-2.76*** (0.40)
Cape Fear effect (dummy)	0.60 (0.46)
Pensacola effect (dummy)	0.03 (0.44)
St. Andrews effect (dummy)	0.48 (0.42)
Lower St. Johns effect (dummy)	0.56 (0.44)
Rate of change (average choices per actor to modify connections)	3.96*** (0.56)

Note: The same model presented in this table were run on larger matrices containing all the estuaries analyzed in Berardo and Scholz (2010). Results do not differ in any significant way. All statistics converged properly. Error estimates based on 4,000 simulations. $^{*}p < .1$, $^{**}p < .05$, $^{***}p < .01$, (two-tail).

degrees or in-degrees are not more likely to increase their perception of procedural fairness. Most of the remaining coefficients in the behavioral evaluation function are also not significant at the .05 or .01 levels of significance.[12] The linear and quadratic shape parameters that were included check for the existence of an upward trend in the perception of procedural fairness and whether the upward drive decreases as the perception of fairness increases, respectively. The two coefficients do not significantly reflect the fact that there is no upward drive in the perception of procedural fairness, at least in the data available for this analysis. The coefficients for the dummy variables measuring differences between the estuaries are insignificant as well, meaning that there are no sizeable differences in the way that perceptions of procedural fairness unfold in the different estuaries.

Finally, the coefficient included to test the Social Influence Hypothesis (Hypothesis 3, whether egos tend to adapt their perceptions of procedural fairness to those of their contacts) almost reaches significance but only at the .1 level, and so it is not possible to rule out with a high degree of confidence the null hypothesis of no social influence in the perception of procedural fairness in the estuaries.

Moving on to the network evaluation function that models how links are created, the results confirm previous findings showing that the selection of ties in estuaries are driven by the search for reciprocal relations and for popular alters who can fulfill a coordination role (Berardo and Scholz 2010).[13] The search for reciprocity and popular alters is particularly appropriate when organizations face a wide range of potential problems in newly developing policy arenas, such as the estuaries I examine, from cooperation dilemmas where bonding capital is needed to detect and punish defection to coordination problems that require central actors to function as distributors of information to nodes located in the periphery of the networks (Scholz, Berardo, and Kile 2008).

There is also one exogenous factor that drives the creation of ties in the estuaries, which is the organizational type of nodes. The results show that there are not significant differences among governmental and nongovernmental actors when they *create* ties, but governmental actors do attract more incoming ties than nongovernmental ones. Governmental actors usually have a greater capacity to act because they are well-endowed with resources that other actors may seek, such as expertise regarding technical issues involving water management, extensive knowledge of the laws and regulations affecting water use and its impact on habitat protection, etc., and so it is only natural that active organizations in the estuaries seek to establish ties with them. However, this finding should not fuel an overly optimistic assessment of the capacity of governmental actors to interact with a varied cadre of organizations in the networks. In fact, the positive "government actor homophily effect" in the estimations implies that there is a tendency for government actors to prefer connections to their own kind, even after controlling for their greater in-degree; the likelihood that governmental actors will link to other governmental actors is higher than the likelihood that they will link to nongovernmental actors.

Finally, the most important finding in the network evaluation function given the focus of this article is the positive and significant effect of the interactive relationship between the ego's perception of procedural fairness and the alter's perception, which provides support for

[12]The only exception is the "rate of change," which simply models the speed by which an actor gets to reconsider a change in the score of the dependent variable (the perception of procedural fairness, in this case).

[13]The *out-degree* parameter should be included in any estimation (Snijders et al. 2010) and indicates the tendency of actors to form ties without seeking to establish any particular type of structure. It is negative and significant, suggesting that organizations in the estuaries do not create ties randomly.

TABLE 3 Preference for Actors with Similar Perceptions of Procedural Fairness (homophily)

$v_i \setminus v_j$	0	1	2	3	4	5	6	7	8	9	10
0	3.87	3.23	2.60	1.96	1.33	0.70	0.06	-0.57	-1.21	-1.84	-2.47
1	3.08	2.58	2.07	1.57	1.07	0.56	0.06	-0.45	-0.95	-1.45	-1.96
2	2.30	1.92	1.55	1.18	0.80	0.43	0.05	-0.32	-0.69	-1.07	-1.44
3	1.51	1.27	1.03	0.78	0.54	0.29	0.05	-0.19	-0.44	-0.68	-0.93
4	0.73	0.62	0.50	0.39	0.27	0.16	0.05	-0.07	-0.18	-0.30	-0.41
5	-0.05	-0.04	-0.02	-0.01	0.01	0.03	0.04	0.06	0.07	0.09	0.11
6	-0.84	-0.69	-0.55	-0.40	-0.25	-0.11	0.04	0.18	0.33	0.48	0.62
7	-1.62	-1.35	-1.07	-0.79	-0.52	-0.24	0.03	0.31	0.59	0.86	1.14
8	-2.41	-2.00	-1.59	-1.19	-0.78	-0.38	0.03	0.44	0.84	1.25	1.65
9	-3.19	-2.65	-2.12	-1.58	-1.05	-0.51	0.03	0.56	1.10	1.63	2.17
10	-3.97	-3.31	-2.64	-1.98	-1.31	-0.64	0.02	0.69	1.35	2.02	2.69

Note: The values in the table are a function of the log odds ratio but also of the scale in which the main variable of interest is measured (in this case, 0 to 10), and so they only illustrate a "preference" with theoretical maximum and minimum values of ∞ and $-\infty$, respectively.

the Homophily Hypothesis (Hypothesis 5). I illustrate the effect of the coefficient on the likelihood of forming ties by considering it together with the coefficients that capture the effects of the ego and the alter's perceptions of procedural fairness on the formation of ties, as shown next:

$$\beta_{\text{ego}} v_i x_{i+} + \beta_{\text{alter}} \sum_j x_{ij} v_j + \beta_{\text{ego x alter}} v_i \sum_j x_{ij} v_j \qquad (3)$$

Using this formula, one can calculate how the creation of a single tie from i to j (x_{ij}=1) reflects the existence of a homophily process (in comparison to a situation in which homophily does not exist; e.g., x_{ij}=0). Since SIENA centers values as explained earlier, the contribution of the tie variable x_{ij} to formula 3 equals

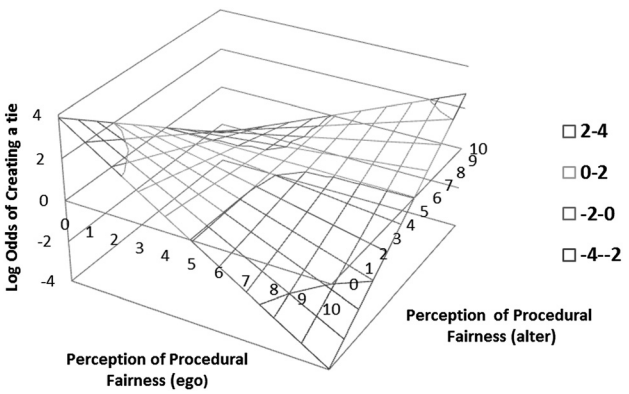
$$\beta_{\text{ego}}(v_i - \bar{v}) + \beta_{\text{alter}}(v_j - \bar{v}) + \beta_{\text{ego x alter}}(v_i - \bar{v})(v_j - \bar{v}) \qquad (4)$$

Where $\bar{v}$ is the average score for procedural fairness (5.41) that is subtracted from the individual scores in the centering procedure. By plugging the relevant log-odds ratios from Table 2 into formula 4, I produce Table 3, which contains values that illustrate how the preference for forming ties increases when the ego and the alter have similar perceptions of procedural fairness.

The diagonal shows the ego's preference for an alter that has an identical score on the perception of procedural fairness, and as we can see, the values in the diagonal are not the highest in each of the lines. This means that egos do not prefer to connect to alters who score *exactly* the same in the variable. However, they do prefer to create ties to others with similar scores on perceptions of procedural fairness. Figure 6 shows these preferences in a 3D graph.

As we can see, when the ego scores 4 or lower on the scale measuring the perception of procedural fairness, the most attractive alters are those who also believe the process of decision making in the estuary is not very fair, with *the* most attractive alter being the one that perceives procedural fairness to be extremely low (v_j = 0). This attractiveness becomes more noticeable as the ego moves toward the lowest points in the scale. Egos that score a value of 0 show the greatest preference for creating a tie to alters that also score that value. On the other hand, for egos that score 5 or higher in the perception of procedural fairness, the top choice is to link to actors who believe

FIGURE 6 Marginal Effect of Alter's Perception of Procedural Fairness on the Attractiveness for Ego of Creating a Tie (conditional on ego's own perception of procedural fairness)



the process is extremely fair. Again, as shown in Figure 6, the effects are not linear. While an ego scoring 6 in the perception of procedural fairness will be more attracted to an alter scoring 10, the attractiveness of this alter will be even greater for an ego scoring a 10. On the whole, we see that egos are more attracted to alters who score more extreme values for the variable and that this relationship gets stronger as egos themselves adopt a more extreme view of the existence of procedural fairness.[14] These findings have important implications for how we think about self-organized networks and governance processes in geographic areas where multiple actors coexist, usually with clearly different policy agendas. I describe these in the following section.

Implications of Findings for Collaborative Governance in Self-Organizing Networks

The results presented in the previous section confirm previous findings showing that self-organized networks in estuaries evolve toward more reciprocity and the search for popular alters who occupy central positions, features that indicate the creation of both bonding and bridging capital that at least in theory can help solving both cooperation and coordination problems (Berardo and Scholz 2010). Yet the result of modeling the coevolution of network ties and perceptions of procedural fairness demands a cautious assessment of the real chances of self-organized networks to contribute to the lasting solution of the collective-action problems in fragmented policy arenas.

The findings show that the level of activity in the networks (indicated by a higher in-degree and out-degree) is not related to changes in the perceptions of procedural fairness and also that actors do not adopt their counterpart's perceptions of procedural fairness (there is no evidence of a social influence process). On the other hand, there is evidence of homophily, since similarity in the perceptions of procedural fairness positively affects the formation of ties. In an interesting extension, the probability of building those ties grows as the alter's perception becomes more extreme!

[14]In additional models that I estimated, I included a measure of ideological positioning in a prodevelopment/proenvironment scale to examine whether there were ego, alter, and homophily effects driven by this variable. All coefficients were nonsignificant, and they contributed to a poorer fit of the model, as indicated by a multiparameter Neyman-Rao score test (Schweinberger 2011).

This finding is coupled with the result showing that there is also homophily based on organizational type. The fact that actors are more likely to come together based on their perceptions of procedural fairness *and* that governmental actors and nongovernmental actors are less likely to mingle as time passes challenges the notion that self-organizing networks may serve as an arena for the effective solution of complex cooperation problems in estuaries. This is so because arriving at those solutions demands the strong commitment of both governmental and nongovernmental actors (Schneider et al. 2003) in contexts where decision-making processes are perceived as procedurally fair by most of them (Lubell 2003).

The existence of these homophilic patterns in the estuaries suggests that over time, the networks may be subject to a ''partitioning effect'' that could eventually lead to the formation of relatively separated camps, thus fragmenting the network and hindering the chances of collaboration on a regional scale. It should also be noticed that the building of ties based on the shared perceptions of procedural fairness is a rather particular manifestation of homophily, since these perceptions are obviously influenced by how decision-making processes unfold in estuaries. In this sense, homophily merely indicates that organizations who feel excluded and those who feel included tend to separate in politically contingent patterns of interactions. Obviously, a problem with this is that the presence of clusters of actors formed on the basis of how fair they think the decision-making processes are could end up resulting in less collaboration at the level of the whole estuary, not more. Needless to say, such an outcome would not serve to mitigate estuary-scale problems, but in all likelihood, it would rather exacerbate them.

Could such fragmentation be mitigated? There is no easy answer to this question given that it is difficult for lawmakers and bureaucrats to steer self-organized networks. However, there are examples of ''external shocks'' to the networks designed to create the conditions that lead to more cooperation, which may be quite successful if judged on their ability to increase interactions between the actors, as shown in Schneider et al.'s (2003) study on the effect of the National Estuary Program in estuarine networks. The NEP was created by the U.S. Congress as part of the amendments to the Clean Water Act that were passed in 1987 under Section 320, and it subsidizes the development of Comprehensive Conservation and Management Plans in selected estuaries to mitigate environmental problems. To design and implement such plans, estuaries with NEP status have Management

Conferences formed by multiple stakeholders from both governmental and nongovernmental sectors, and so homophily based on organizational type is less likely. By providing a setting to share and discuss many different views about environmental problems that numerous stakeholders have, management conferences reduce the likelihood of long-term conflict by—among other things—improving the overall sense that the decision-making processes are fair to all actors involved in them (Lubell 2004). In well-functioning arenas where all or a large majority of stakeholders feel that procedural fairness is adequate, homophily would not lead to a fragmentation in the network of interactions among actors, but rather to a situation where most stakeholders increase their level of activity and the network becomes denser, which can help solve cooperation problems more quickly (Berardo and Scholz 2010).

Unfortunately, it is not possible to assess whether this is what happens in NEP estuaries with the data at hand. The project that produced the data that I use in this article collected information in 12 NEP estuaries, but the survey respondents in those estuaries were selected based on random-sampling techniques that make the data unsuited for the type of network analysis presented here.[15] Future research thus needs to overcome this limitation by providing scholars and policy practitioners with improved analyses to better understand the emergence of perceptions of high procedural fairness that facilitate cooperative behavior in complex decision-making arenas where stakeholders have a good track record of solving "wicked" policy problems.

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[15]The respondents in non-NEP estuaries, on the other hand, were identified with an extensive set of seed interviews that contained a name generator and made possible the identification of all (or the large majority) of organizations involved in estuary networks.

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